INDUSTRIAL AUTOMATION

© TVET SSP

LEARNER GUIDE

National Vocational Certificate Level 4

Version 1 - September, 2019

INDUSTRIAL AUTOMATION

© TVET SSP

Version 1 - September, 2019

Introduction

Welcome to your Learner's Guide for the Industrial Automation Program. It will help you to complete the program and to go on to complete further study or go straight into employment. The Industrial Automationprogram is to engage young people with a program of development that will provide them with the knowledge, skills and understanding to start this career in Pakistan. The program has been developed to address specific issues, such as the national, regional and local cultures, the manpower availability within the country, and meeting and exceeding sthe needs and expectations of their customers.

The main elements of your learner's guide are:

- **Introduction:**
  This includes a brief description of your guide and guidelines for you to use it effectively

- **Modules:**

-
  The modules form the sections in your learner's guide

- **Learning Units:**
  Learning Units are the main sections within each module

- **Learning outcomes**:
  Learning outcomes of each learning units are taken from the curriculum document

- **Learning Elements:**
  ➢ This is the main content of your learner's guide with detail of the knowledge and skills (practical activities, projects, assignments, practices etc.) you will require to achieve learning outcomes stated in the curriculum
  ➢ This section will include examples, photographs and illustrations relating to each learning outcome

- **Summary of modules**:
  This contains the summary of the modules that make up your learner's guide

- **Frequently asked questions**:
  These have been added to provide further explanation and clarity on some of the difficult concepts and areas. This further helps you in preparing for your assessment.

INDUSTRIAL AUTOMATION

Module-19

LEARNER GUIDE

National Vocational Certificate Level 4

Version 1 - September, 2019

Module 19: 071400940 Configure AC Drives and Motors

Objective of the Module: The aim of this module to get knowledge, skills and understanding toconfigure ac drives and motors

Duration: 250 hours   **Theory:**50 Hours   **Practical:**200 Hours

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1: OperateAC Drives and Motors	**The learner will be able to perform following tasks after the completion of this module:** • Select Tools, Motors and Drives as per requirement. • Perform Wiring of motor, drives and controllers as per requirement. • Set parameters of drives and controller as per requirement. • Troubleshoot motor and drives.	**Tools to be used for AC Drives and Motors** • Electrical standard tool kit • Standard instruments • Tool identification and selection • Tool operation and safety precaution while using the tools **Basic principles of Motors** • Electro Magnet • Electromagnetic induction • Faraday's Law • Difference between AC and DC motors • Difference between single phase and three phase motors • Difference between induction motor and servo motor **Wiring of Drives and motors** • Main power wiring of induction motor • Main power wiring of servo	• White board • Multimedia • Computer system /Internet • AC Drives /VFDs • AC Motors • Electrical Tool Kit

		motor	
		• Variable frequency drive wiring	
		• Servo drive wiring	
		• External source wiring of VFD	
		• VFD wiring for multispeed point	
		• Servo drive encoders pin wiring	
		Parameter setting of VFD	
		• Operation of keys located on Keypad of VFD	
		• Opening of parameter using keypad	
		• Setting of basic parameter of VFD	
		• Setting of the parameters for speed control of induction motor	
		• Observation of the change occurred on motor speed after changing the parameters	
		• Parameter setting for torque control of induction motor	
		• Parameter setting for voltage levels	
		• Parameter setting for motor acceleration time	
		• Parameter setting for the motor deceleration time	

		• Reset of VFD parameters on default • Servo drive basic parameter setting • Servo drive voltage level parameter setting • Servo drive mode parameter setting • Servo Drive jog speed setting parameter • Reset of Servo parameters on default	
LU2: Integrate AC Drives with PLC	**The trainee will be able to:** • Identify communication protocols of drives and controllers as per requirement • Control Servo Operation using PLC as per requirement • Control Variable Frequency Drive (VFD) operation using PLC as per requirement • Interface encoders with PLC and drives as per requirement • Troubleshoot drives	**Communication protocol and medium setting for drive interfacing** • Interfacing of VFD with PLC through Modbus • Interfacing of VFD with PLC through simple RS485 • Interfacing of VFD with PLC HMI thorough RS485 • Interfacing of Servo drive with PLC thorough Ethernet • Interfacing of Servo drive with PLC through Modbus • Interfacing of Servo drive with PLC through 45 pin communication cable • Interfacing of Servo drive with	• White board • Multimedia • Computer system /Internet • AC Drives /VFDs • AC Motors • Electrical Tool Kit

	communication	HMI through Modbus	
		• Interfacing of Servo drive with Computer through SDA cable and SDA software.	
		Working of Rotary Encoder	
		• Encoder operation	
		• Types of encoders	
		• Encoder interfacing with transistor type PLC	
		• Reading the pulses in software form encoder	
		• Position determination of motor using encoder interfaced with PLC	
		• RPM determination of motor using encoder interfaced with PLC	
		Communication accessories	
		• Modbus communication	
		• RS485	
		• Ethernet	
		• 45 pin connecter	
		• Encoder cable	
		• Simple jumper wire	
		VFD Control System	
		• Speed control of induction motor using external source of	

		frequency in VFD	
		• Speed control of induction motor using using VFD through PLC	
		• Direction control of induction motor using external terminals	
		• Direction control of induction motor using using VFD through PLC	
		• Torque control of induction motor using external terminals and PLC	
		• Speed monitoring of induction motor using encoder interfaced with PLC and VFD	
		• Speed control of induction motor using encoder interfaced with PLC and VFD	
		• Position monitoring of induction motor using encoder interfaced with PLC and VFD	
		• Position control of induction motor using encoder interfaced with PLC and VFD	
		• Direction monitoring of induction motor using encoder interfaced with PLC and VFD	
		• Direction control of induction motor using encoder interfaced	

| | | with PLC and VFD

Servo Control System

• Servo jog mode staring

• Use of Servo Drive and control the speed of servo motor from keypad of servo drive by setting the parameter

• Use of Servo Drive and control the direction of servo motor from keypad of servo drive by setting the parameter

• Use of Servo Drive and control the torque of servo motor from keypad of servo drive by setting the parameter

• Use of Servo Drive and control the position of servo motor from keypad of servo drive by setting the parameter

• Reset of servo drive on default setting

• Interfacing of Servo Drive with PLC and speed control

• Interfacing of Servo Drive with PLC and direction control

• Interfacing of Servo Drive with PLC and control

• Interfacing of Servo Drive with PLC and position control | |

		• control the speed, direction, position and torque of servo motor by link communication through PLC programming	
		• Use of servo online parameter setting software and setting ofparameter of servo drive	
		• Development of different process control program using VFD and PLC interfacing than control and monitor these program from HMI	
		• Development of different process control program using Servo Drive and PLC interfacing than control and monitor these program from HMI	

Testing and troubleshooting

- Testing of VFD control system
- Testing of induction motor
- Communication testing of VFD and PLC
- Testing of Servo control system
- Testing of servo motor
- Communication testing of Servo drive and PLC
- Reset of VFD
- Reset of Servo Drive

		- Remedial solution in VFD control system - Remedial solution of Servo control system	

INDUSTRIAL AUTOMATION

© TVET SSP

Module-20
LEARNER GUIDE
National Vocational Certificate Level 4

Version 1 - September, 2019

Module 20 : 071400941 Operate Industrial Robot

Objective of the Module: The aim of this module to get knowledge, skills and understanding to operate industrial robot

Duration: 140 hours **Theory:**28 Hours **Practical:**112 Hours

Learning Unit	Learning Outcomes	Learning Elements	Materials Required

LU1: Install industrial robot	**The trainee will be able to learn :**
	
	• Select tools & accessories as per requirement
	
	• Connect cables and peripheral as per requirement
	
	• Integrate pneumatic / hydraulic system with robot as per requirement
	
	• Take safety measures as per requirement
		• **The manufacturer's instructions as per ;**
		  i. Installation manual including unpacking
		  ii. Assembly
		  iii. Electrical connections
		  iv. Software installation
		  v. Communication establishment.
		
		• Assembling of the robot following the installation instructions provided by the manufacturer, including proper connections of the cables and peripherals (i.e. computers, teach-pendant, etc.).
		
		• Installing the operating software on the computer with proper connections with the hardware of the robot.
		
		• Calibrating the sensors before the first run of the robot.
		
		• Understanding the connections of pneumatic/hydraulic units with the
			• White board
			• Multimedia
			• Computer system /Internet
			• Electrical Tool Kit
			• 6 DOF Robotic manipulator with all the peripherals including the gripper
			• Pneumatic/ hydraulic power unit

		robot through standard solenoid operated valve modules.	
		• Understanding the component-level checking of the installed modules and peripherals.	
		• Operational knowledge of the first dry run of the robot including the homing operation, reaching to a specific position, etc.	
LU2: Develop program for robotic applications	**The trainee will be able to perform following tasks:** • Develop program using Teach Pendant (online) • Simulate Robot Program as per requirement. • Develop program using Robots Software (offline)	• Understanding the programming of the robot by adding different positions using the teach-pendant. • Understanding the robot movements using the controls available on the teach-pendant both in joint-space and task-space. • Configuring the robot in its programming software and then programming the robot by adding different positions using the software. • Writing a basic set of movement commands in the robot's programming software and then simulating the response of the robot. • Understanding the physical movement of robot using the options available in the programming software (both in	• White board • Multimedia • Computer system /Internet • Electrical Tool Kit • 6 DOF Robotic manipulator with all the peripherals including the gripper • Pneumatic/ hydraulic power unit with solenoid valves • Components for robotic assembly and pick-and-place exercises

		joint-space and task-space)	
		• Study the concepts of robot configuration, work envelop, task-space and joint-space.	
		• Programming the robot to perform different tasks in different settings such as:	
		i. Robot-gripper movement along cartesian axis, under different speed settings	
		ii. Pick and place exercise	
		iii. Pick and place exercise with waypoints	
		iv. Pick and place activity with obstacle avoidance	
		v. Basic Assembly Operation with Linear Movements	
		vi. Assembly Operation with Linear Traverse and Twist	
		vii. Disassembly Operations	
LU3: Troubleshoot / Debug Robot	**The trainee will be able to perform following duties:** • Select Tools as per requirement. • Edit and debug a	• Understanding different error-codes (most frequently occurring) of the robot and their corresponding causes. • Understanding the maintenance	• White board • Multimedia • Computer system /Internet • Electrical Tool Kit • 6 DOF Robotic manipulator with all the peripherals including the gripper

		program using Teach Pendant /Software. • Troubleshoot Control Panel and Drives.	manual of the robot with strong emphasis to preventive maintenance practices. • Troubleshooting the hardware-related faults including, but not limited to, hardware-connection faults, communication errors, sensor noise/disconnection, limit sensing, etc. • Troubleshooting the software-related faults such as faulty program-sequence, syntax errors, etc. • Isolating and debugging the programs in robot-alone settings. • Isolating and debugging the programs in Robot-with-Peripheral settings. • Troubleshooting the drive interfaces with the robot. • Troubleshooting the Robot Program in simulation mode to fulfill all the task requirements.	• Pneumatic/ hydraulic power unit with solenoid valves • Components for robotic assembly and pick-and-place exercises

Module Summary:

Module	Learning Units	Duration
Module 19: Configure AC Drives and Motors	**LU1:** Operate AC Drives and Motors **LU2:** Integrate AC Drives with PLC	250
Module 20: Operate Industrial Robot	**LU1:** Install industrial robot **LU2:** Develop programs for robotic applications **LU3:** Troubleshoot / Debug Robot	140

Frequently Asked Questions
(FAQs):

Q: 1 What Is Automation**?**

Ans :

Automation is delegation of human control functions to technical equipment for increasing productivity, better quality, reduced cost & increased in safety working conditions.

Q : 2 What Are The Different Components Used In Automation?

Ans:

The components of automation system include

- Sensors for sensing the input parameters (RTD, Thermocouple, Pressure, Flow, Level; etc)
- Transmitters for transmitting the raw signal in electrical form
- Control system which includes PLC, DCS & PID controllers
- Output devices / actuators like drives, control valves.

Q :3 What Are The Different Control Systems Used In Automation?

Ans:

- PID Controller based control system
- PLC based control system
- DCS based Control system
- PC Based automation system

Q :4 Explain PID Based Control System?

Ans:

PID (Proportional Integral Derivative) is the algorithm widely used in closed loop control. The PID controller takes care of closed loop control in plant. A number of PID controllers with single or multiple loop can be taken on network.

PID Controllers are widely for independent loops. Although some logic can be implemented but not much of sequential logic can be implemented in PIDs.

Q : 5. What is Difference Between PLC & Relay Logic Control ?

Ans:

- PLC can be programmed whereas a relay cannot.
- PLC works for analog I/Os such as PID loops etc. whereas a relay cannot
- PLC is much more advanced as compared to relay.
- Modifications in relay base circuit is difficult compared to PLCs

Q : 6 Which Are The Leading PLC Providers ?

Ans :

The leading PLC providers include

- Rockwell Automation : Allen Bradley (Micrologix, SLC, PLC, Control Logix)
- Siemens (S7 200, S7 300 , S7 400)
- Grouppe Schneider : Modicon (Nano, Micro, Premium, Quantum)
- GE Fanuc : Versa, Series 90-30, 90-70
- Mitsubishi
- Delta
- Fatek

Q : 7 What Types Of Sensors Are Used For Measuring Different Parameters?

Ans :

- Temperature sensors – RTD, Thermocouple, Thermister
- Pressure Sensor – Borden Tube, Bellows, Strain gauge
- Flow sensor – Pitot tube, Orifice, Ultrasonic+
- Level, Conductivity, Density, Ph

Q :8 What is Competency Based Training (CBT) and how is it different from currently offered trainings in institutes?

Ans:

Competency-based training (CBT) is an approach to vocational education and training that places emphasis on what a person can do in the workplace as a result of completing a program of training. Compared to conventional programs, the competency based training is not primarily content based; it rather focuses on the competence requirement of the envisaged job role. The whole qualification refers to certain industry standard criterion and is modularized in nature rather than being course oriented.

Q :9 What is the passing criterion for CBT certificate?

Ans:

The candidate will be required to be declared "Competent" in the summative assessment to attain the certificate.

Q:10 What are the entry requirements for Industrial Automation?

Ans: The entry requirement for this course is Matric Science or equivalent.

Q :11 How can I progress in my educational career after attaining this certificate?

Ans:

You shall be eligible to take admission in the National Vocational Certificate Level-2 in Industrial Automation Technician. You shall be able to progress further to National Vocational Certificate Level-3 & Level-4.

Q:12 If one can have the experience and skills mentioned in the competency standards, does he still need to attend the course to attain this certificate?

Ans:

You may opt to take part in the Recognition of Prior Learning (RPL) program by contacting the relevant training institute and getting assessed by providing the required evidences.

Q:13 Is there any age restriction for entry in this course or Recognition of Prior Learning program (RPL)?

Ans:

There are no age restrictions to enter this course or take up the Recognition of Prior Learning program.

Q:14 What is the duration of this course?

Ans:

The duration of the course is 1,810 hrs. (2.5 Years)

Q:15 What are the class timings?

Ans:

The classes are normally offered 26 days a month from 08:00am to 01:30pm. These may vary according to the practices of certain institutes.

Q: 16 What is equivalence of this certificate with other qualifications?

Ans:

As per the national vocational qualifications framework, the level-4 certificate is equivalent to Matriculation. The criteria for equivalence and equivalence certificate can be obtained from The Inter Board Committee of Chairmen (IBCC).

Q: 17 What is the importance of this certificate in National and International job market?

Ans: This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). These standards are also recognized worldwide as all the standards are coded using international methodology and are accessible to the employers worldwide through NAVTTC website.

Q: 18 which jobs can I get after attaining this certificate? Are there job for this certificate in public sector as well?

Ans:

You shall be able to take up jobs in the operation, maintenance, automating manufacturing, process and any kind of industry.

Q:19 What are possible career progressions in industry after attaining this certificate?

Ans:

You shall be able to progress up to the level of supervisor after attaining sufficient experience, knowledge and skills during the job. Attaining additional relevant qualifications may aid your career advancement to even higher levels.

Q: 20 Is this certificate recognized by any competent authority in Pakistan?

Ans:

This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). The official certificates shall be awarded by the relevant certificate awarding body.

Q:21 Is on-the-job training mandatory for this certificate? If yes, what is the duration of on-the-job training?

Ans:

On-the-job training is not a requirement for final / summative assessment of this certificate. However, taking up on-the-job training after or during the course work may add your chances to get a job afterwards.

Q: 22 How much salary can I get on job after attaining this certificate?

Ans:

The minimum wages announced by the Government of Pakistan in 2019 are PKR 17,500. This may vary in subsequent years and different regions of the country. Progressive employers may pay more than the mentioned amount.

Q: 23 What is the teaching language of this course?

Ans:

The leaching language of this course is English/Urdu.

Q: 24 Is it possible to switch to other certificate programs during the course?

Ans: There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.

Q: 25 What is the examination / assessment system in this program?

Ans:

Competency based assessments are organized by training institutes during the course which serve the purpose of assessing the progress and preparation of each student. Final / summative assessments are organized by the relevant qualification awarding bodies at the end of the certificate program. You shall be required to be declared "Competent" in the summative assessment to attain the certificate.

Q: 26 What kind of freelancer activities can be started. ?

Ans:

You can start your small business of providing services including automating the machines with the focus of PLC programming.

MLTIPLE CHOICE QUESTIONS (MCQs)

MODULE: 19 CONFIGURE AC DRIVES AND MOTORS

Q:1 VFD is preferred on Servo drive where _____ is required.

   a. Accuracy   b. Load is light   c. **Load is heavy**   d. All of these

Q:2 Servo Drive is preferred on VFD where _____ is required.

   a. Accuracy   b. Position control   c. Load is heavy **d. Both a & b**

Q:3 Feedback of encoder is used to control the _____of motor.

   a. **Torque**   b. Position   c. direction   d. **Both b & c**

Q:4 Servo Drive is use to control the _____ of motor

    a. Speed   b. Position   c. direction   **d. all of these**

Q:5 VFD is use to control the _____ of motor

    a. **Speed**   b. Position   c. None of these   d. both a & b

Q:6 _____ based switching PLC is used to interface with encoder

    a. **Transistor**   b. Relay c. Triac   d. None of these

MODULE: 20 OPERATE INDUSTRIAL ROBOT

Q:1   Robot is derived from Czech word

(A) Rabota (B) **Robota** (C) Rebota (D) Ribota

Q:2   A Robot is a

(A) Programmable(B) Multi functional manipulator

(C)   **Both (A) and (B)**(D) None of the above

Q:3 The main objective(s) of Industrial robot is to

(A) To minimize the labor requirement(B) To increase productivity

(C) To enhance the life of production machines(D) **All of the above**

Q:4   The following is true for a Robot and NC Machine

(A) **Similar power drive technology is used in both**

B) Different feedback systems are used in both

(C) Programming is same for both(D) All of the above

Q: 5   Drives are also known as

(A) **Actuators**(B) Controller(C) Sensors(D) Manipulator

Q: 6 Clockwise of Anti clockwise rotation about the vertical axis to the perpendicular arm is provided through

(A) Shoulder swivel   (B) Elbow extension   (C) **Arm sweep** (D) Wrist bend

Q:7 Radial movement (in & out) to the manipulator arm is provided by

(A) **Elbow extension**(B) Wrist bend(C) Wrist swivel(D) Wrist yaw

Q:8 Industrial Robots are generally designed to carry which of the following coordinate system(s).

(A) Cartesian coordinate systems(B) Polar coordinate systems

(C) Cylindrical coordinate system(D) **All of the above**

Q: 9 The Robot designed with Cartesian coordinate systems has

(A) **Three linear movements**(B) Three rotational movements

(C) Two linear and one rotational movement

(D) Two rotational and one linear movement

Q: 10 The Robot designed with Polar coordinate systems has

(A) Three linear movements(B) Three rotational movements

(C) Two linear and one rotational movement

(D) **Two rotational and one linear movement**

 Q:11 The Robot designed with cylindrical coordinate systems has

(A) Three linear movements(B) Three rotational movements

(C) **Two linear and one rotational movement**

(D) Two rotational and one linear movement

 Q:12 Which of the following work is done by General purpose robot?

(A) Part picking (B) Welding (C) Spray painting (D) **All of the above**

 Q:13 The following drive is used for lighter class of Robot.

(A) **Pneumatic drive**(B) Hydraulic drive(C) Electric drive(D) All of the above

 Q:14 Internal state sensors are used for measuring _____ of the end effector.

(A) Position(B) Position & Velocity(C) Velocity & Acceleration

(D) Position, Velocity & Acceleration

Q:15 Which of the following sensors determines the relationship of the robot and its environment and the objects handled by it.

(A) Internal State sensors(B) External State sensors

(C) **Both (A) and (B)**(D) None of the above